Available online at www.ijpab.com

DOI: http://dx.doi.org/10.18782/2582-2845.9123

ISSN: 2582 – 2845

Ind. J. Pure App. Biosci. (2024) *12*(5), 28-36

Indian Journal of Pure & Applied Biosciences

Peer-Reviewed, Refereed, Open Access Journal

Research Article

Comparative Study of Seed Germination in Textile Industry Wastewater and ZnO Nanoparticles Treated Textile Industry Wastewater

Rajani[1*], Rishi Kesh Meena[2]

[1]Department of Botany, Govt. P.G. College, Kekri, India

[2]Department of Botany, University of Rajasthan, Jaipur, India

*Corresponding Author E-mail: rajaniyadav9083@gmail.com

Received: 13.06.2024 | Revised: 29.08.2024 | Accepted: 16.09.2024

ABSTRACT

Textile industries are the most environmentally unsustainable industry due to the consumption of a lot of fresh water during textile processing and the effluent of a large quantity of highly polluted wastewater after textile processing. Due to the unavailability of fresh water, textile effluent is utilized in agricultural practice. Textile wastewater contains a high amount of chemicals and colours. Hence, fertile agricultural land turns into the barren soil. Nanotechnology can resolve this problem by treating textile wastewater positively. In this study, we examined the effects of textile wastewater on the germination of wheat seeds. On the other hand, we also observe the effectiveness of ZnO NPs in the treatment of textile wastewater and seed germination rate in this water.

Keywords: *Nanoparticles; Seed germination; Textile wastewater; ZnO NPs.*

INTRODUCTION

The textile industry uses a lot of fresh water. Water is needed for many processing steps in textile industries, and as a result, a large amount of wastewater is produced. To combat the increasing demand for fresh water and shortage of fresh water, textile wastewater is used in agricultural land instead of disposing (Lellis et al., 2019; & Singh et al., 2021). Textile wastewater is enormously used to irrigate agricultural land because of a shortage of freshwater. The untreated industrial wastewater used in agricultural activities can harm the soil environment, soil fertility, and the food chain (Singh et al., 2021, & Mohan & Shukla, 2022).

Kanan et al. (2014) reported that textile wastewater changed the physiochemical parameters of water and soil. Textile wastewater changes the salinity and sodality of soil, which affects crop production. It also changes water quality by changing the pH, temperature, BOD, COD, turbidity, and TDS (Total dissolved solids) of water bodies. Begum et al. (2011) observed that the intake of vital plant nutrients was antagonistically impacted by contaminated water.

Cite this article: Rajani & Meena, R. K. (2024). Comparative Study of Seed Germination in Textile Industry Wastewater and ZnO Nanoparticles Treated Textile Industry Wastewater, *Ind. J. Pure App. Biosci. 12*(5), 28-36. doi: http://dx.doi.org/10.18782/2582-2845.9123

Rice plants could not properly absorb nutrients from textile wastewater, which affected the growth and output of rice.

Najam-us-Sahar et al. (2017) also reported the negative impacts of textile wastewater on wheat plant growth and crop productivity (*Triticum aestivum* L.). Textile wastewater also affects seed germination, plant biomass, shoot and root growth, chlorophyll and carotenoid contents, photosynthetic rate, etc. (Kaushik et al., 2005; Garg & Kaushik, 2008, & Khan et al., 2011). In soybean crops, textile effluent water affected the crop at all stages of seed germination, seedling growth, shoot and root length, root nodules, number of lateral roots and leaves, and total chlorophyll content (Ravi et al., 2014).

Pokhriya et al. (2020) reported that textile wastewater irrigated agricultural land showed a reduced bacterial population and dehydrogenase enzyme activity in the soil. Soil changes are directly correlated with soil health and crop yield production. Any physiochemical change in the soil also affects soil fertility and soil characteristics, resulting in barren or reduced productivity.

Roohi et al. 2016; described that textile wastewater altered soil's biological health and physiochemical properties, which is directly related to agricultural productivity. Untreated textile wastewater also affects the nutrients and mineral absorption capacity of plants (Begum et al., 2016). Mehdi et al. (2012) examined the effects of textile wastewater on seed germination, crop yield, nutrient uptake, and soil characteristics. Results support the negative effects of textile effluents on crop and agricultural land. All these factors affect agricultural land and crop production.

Biological, physical, and chemical processes are also available for wastewater treatment, but the huge quantity of contaminated water and the slow process of remediation, which is costly, make them insufficient methods for wastewater treatment (Robinson et al., 2001). So the consumption of industrial effluent in the irrigation of agricultural lands is increased with increasing food demands and shortage of freshwater (Holkar et al., 2016). With the harm to agricultural land and crop yield, irrigation with contaminated water also affects the ecosystem. Heavy metals and other chemical compounds accumulate in plant parts, transfer through the food chain, and become part of the food cycle (Singh et al., 2021).

Nanotechnology is a multidisciplinary field focused on healthcare, electronics, agriculture, energy, material sciences, and environmental protection (Tourinho et al., 2012). It has the potential to revolutionize agriculture by enhancing productivity, sustainability, and soil efficiency (Ghormade et al., 2011). Fig. 1 shows some of the key applications of nanotechnology in agriculture.

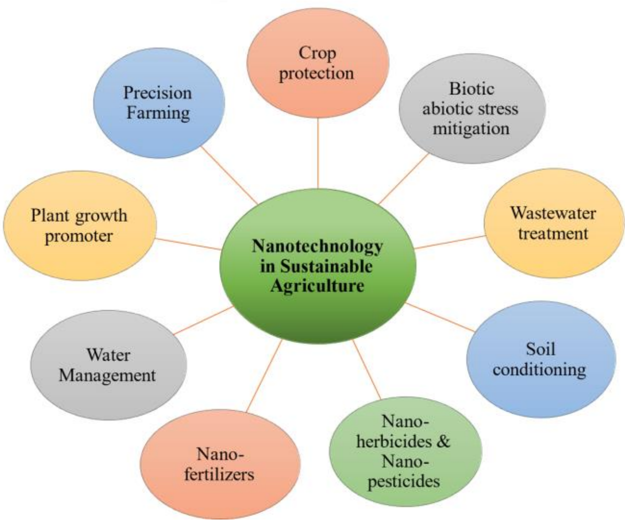

Fig1. Various roles of nanotechnology in sustainable agriculture

ZnO nanoparticles are good photocatalysts and also absorb pollutants on their surface. ZnO NPs can be used for the treatment of not only textile industry wastewater but also other industrial and municipal wastewater (Desa et al., 2019). Runoff of wastewater and addition into water bodies, such as ponds, lakes, rivers, and finally, the ocean, is responsible for aquatic as well as terrestrial ecosystem pollution. Treatment of wastewater reduces the hazards of various pollutants such as heavy metals, dyes and other chemical compounds (Sadiq et al., 2021). In our previous experiments, ZnO NPs photodegraded textile wastewater and made them more useful for further use. In this experiment, we observed the effects of textile industry wastewater and ZnO NPs treated water on wheat seed germination.

Several types of research have examined the impacts of wastewater on crop yield and soil health. In this study, we assessed the impact of textile wastewater on seed germination capacity, along with the role of ZnO nanoparticles in purifying textile wastewater and seed germination capacity in ZnO NPs treated textile wastewater.

MATERIALS AND METHODS

Wheat seeds were purchased from the local grain market of Jaipur. Seed feasibility was examined using the TTC (2,3,5 triphenyl tetrazolium chloride) method. The wheat seeds were 100 per cent viable. The seeds were washed off under tap water after that, distilled water to remove dust particles and other contaminants. Seed germination experiment performed in Petri dishes.

Textile wastewater was collected from the Sanganer textile industrial area, which we used in our previous studies. Green ZnO NPs treated textile wastewater collected from our previous photocatalytic experiments and stored for further utilization for their effects on seed germination experiment (Rajani et al., 2023). For the control conditions, tap water was used as freshwater for seed germination.

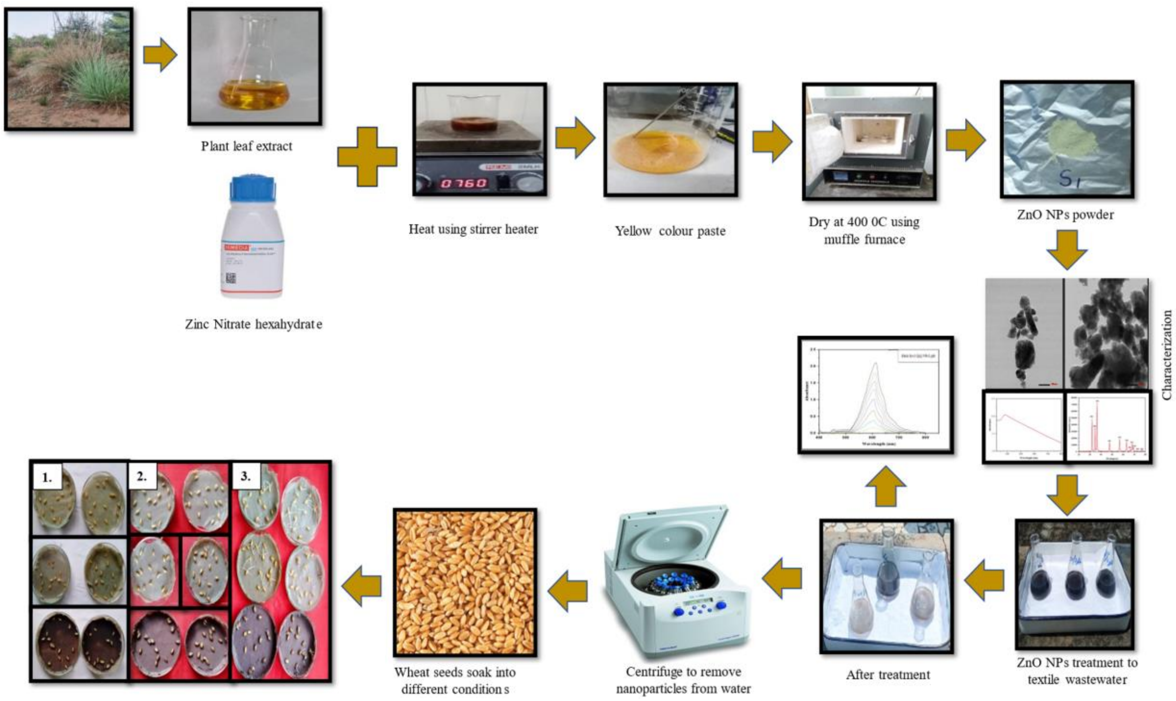

Fig. 2 Process of green ZnO NPs synthesis, textile wastewater treatment and seed germination experiment

2. Experimental Setup

Three sets of experiments were implemented in triplicate to evaluate seed germination capacity in different conditions-

a. Control condition (freshwater),
b. Textile wastewater and
c. Textile wastewater treated with green ZnO nanoparticles.

After photocatalytic degradation of textile dyes, the ZnO NPs-treated water was collected for the seed germination experiment. The nanoparticle-treated water was subjected to centrifugation to remove ZnO NPs (Fig. 2). After centrifugation, ZnO NPs settled down in the bottom, and the supernatant was collected to obtain nanoparticle-free water.

Seed germination experiment performed in Petri plates. Blotting paper was cut down into the size of Petri plates and placed into Petri plates. Three Petri plates with blotter soaked into each in one type of water. Some seeds of wheat (15 seeds) were put into each Petri plate and left for germination. Seed germination was observed after every 12 hours of intervals. The blotting paper was also kept wet from time to time by soaking them in their sample water. This experiment was performed in October month, and the temperature was optimum (around 27 ^{0}C) for wheat seed germination.

Observations

Seed germination was observed after 12 hours of time intervals (12, 24, and 36 hours). Wheat seeds started to germinate only after 24 hours in fresh water and textile wastewater treated with green ZnO nanoparticles, but no germination was observed in dye-contaminated water. Textile wastewater treated with green ZnO nanoparticles acts as freshwater, and the results were almost similar to freshwater.

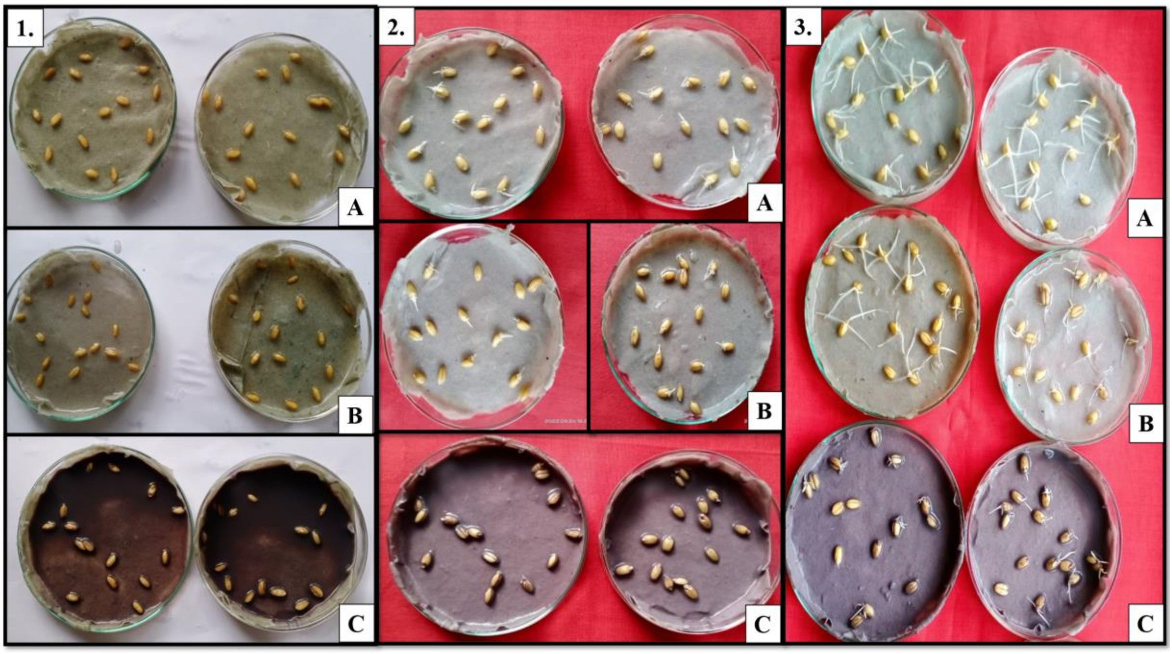

Fig. 3 (1-3): Wheat seed germination experiment at 0, 24 and 36 hours. (A) Freshwater (B) ZnO NPs treated textile wastewater (C) Textile wastewater

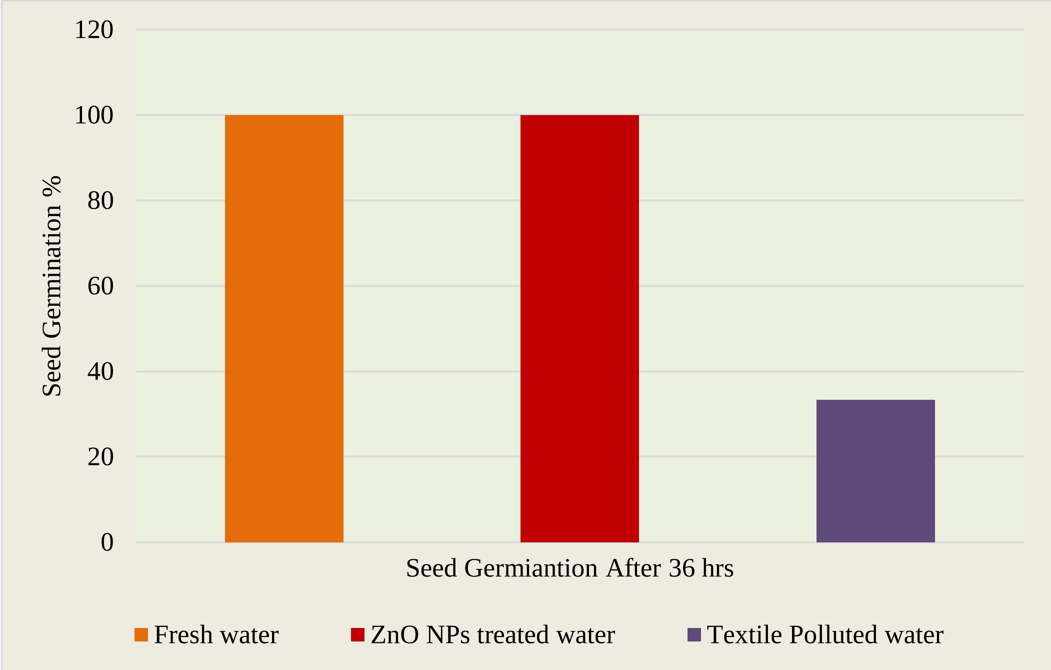

Fig. 4 Seed germination percentage in all three conditions viz. freshwater, ZnO NPs treated textile wastewater, textile wastewater

After 36 hours, seedings were continuously elongated in fresh water and textile wastewater treated with green ZnO nanoparticles. However, seeds started to germinate in dye-contaminated water after 36 hours. It was observed that dye-contaminated water slows down the germination process. A high pH of textile wastewater also affects or reduces the germination rate of seeds.

The results suggested the efficacy of green ZnO NPs in textile wastewater treatment. Treatment of textile wastewater with biosynthesized ZnO nanoparticles makes dye-contaminated water more approachable, useful, less toxic, and safe for agricultural use.

RESULT AND DISCUSSION

The results of seed germination capacity experiments in different conditions, viz., control conditions (freshwater), textile wastewater, and textile wastewater treated with green ZnO nanoparticles, showed a reduction in germination in textile wastewater.

Sprouting of wheat seeds started after 24 hours of soaking in freshwater (Yang et al., 2011). In this study, the wheat seeds germination ratio in freshwater and ZnO nanoparticles treated wastewater was almost similar. Seeds started sprouting after 24 hours in both freshwater and ZnO nanoparticles treated wastewater (Fig. 3). After 36 hours, wheat seeds showed a 100% germination rate in both freshwater and ZnO nanoparticles treated wastewater. In dye-contaminated wastewater, seeds showed a reduced germination rate and required more time to germinate. After 36 hours, only 70% of the seed germinated (Fig. 4). Results showed that dye-contaminated wastewater also slowed down the seed germination and growth of seedlings as compared to freshwater and ZnO nanoparticles treated wastewater. In this experiment, ZnO NPs were removed from water by centrifugation. Some research showed the negative impacts of nanomaterials on seed germination and seedling development (Lin et al., 2007, & Yaqoob et al., 2018). However, some findings claim positive impacts of nanoparticles on seed sprouting and plant growth (Baz et al., 2020, & Guo et al., 2022).

Table1. Wheat seed germination in fresh water, textile runoff water and ZnO NPs treated water

Time duration	Seed Germination in three Different Conditions		
	Fresh Water	**Textile Runoff Water**	**ZnO NPs treated Water**
0 hour	No germination	No germination	No germination
24 hours	Seeds start sprouting	No germination observed	Seeds start sprouting
36 hours	All seeds sprouted	Only some seeds start sprouting (Delayed Sprouting)	All seeds sprouted

Textile polluted wastewater affects seed germination and seedling growth of some winter crops, viz. *Raphanus sativus*, *Brassica campastris*, and *Brassica napus* compared to freshwater (Rehman et al., 2009). Textile effluents also affect the soil bacterium, which is directly related to soil health and crop yield (Khan & Malik, 2018). Many researches showed the effects of textile wastewater on seeds of *Glycine max (*soybean), *Cicer arietinum* L., *Vigna radiata* seeds germination and seedling growth (Yousaf et al., 2010; Rathod et al., 2015, & Kothari et al., 2022).

In our previous study, these nanoparticles also showed excellent antioxidant, antibacterial, and photocatalytic activity (Rajani et al., 2023). Green synthesis of zinc oxide (ZnO) nanoparticles involves eco-friendly methods that use natural, non-toxic materials and processes. Numerous properties of green ZnO NPs make them more suitable and a key point of interest for scientists to make a more effective product in less effort.

CONCLUSIONS

In our study, it is concluded that textile wastewater negatively affected seed germination, seedlings growth as well as crop production. ZnO nanoparticles treated wastewater did not affect seed germination. ZnO NPs treated wastewater is almost equivalent to freshwater. So it can be proven that the treatment of textile wastewater with ZnO NPs can be a better alternative instead of the direct use of textile wastewater as agricultural land irrigation. Results provide an idea for the better usage of textile wastewater after being treated with green ZnO nanoparticles to make it safer and more useful for agriculture. Besides this, green nanotechnology can reduce the risk of nanotoxicity and provide an eco-sustainable approach to water treatment.

Acknowledgement

The authors are grateful to the Department of Botany, University of Rajasthan, Jaipur, India, for providing research facilities.

Authors contributions

Rajani: conceptualization, formal analysis, investigation, writing-original draft, Rishi Kesh Meena: investigations, writing-review and editing.

Ethics approval

Not applicable

Conflict of interest

The authors declare no competing interests.

REFERENCES

Baz, H., Creech, M., Chen, J., Gong, H., Bradford, K., & Huo, H. (2020). Water-soluble carbon nanoparticles improve seed germination and post-germination growth of lettuce under salinity stress. *Agronomy*, *10*(8), 1192. https://doi.org/10.3390/agronomy10081192

Begum, R. A., Zaman, M. W., Mondol, A. T. M. A. I., Islam, M. S., & Hossain, M. F. (2011). Effects of textile industrial waste water and uptake of nutrients on the yield of rice. *Bangladesh Journal of Agricultural Research*, *36*(2), 319-331. https://doi.org/10.3329/bjar.v36i2.9260

Desa, A. L., Hairom, N. H. H., Ng, L. Y., Ng, C. Y., Ahmad, M. K., & Mohammad, A. W. (2019). Industrial textile wastewater treatment via membrane photocatalytic reactor (MPR) in the presence of ZnO-PEG nanoparticles and tight ultrafiltration. *Journal of Water Process Engineering*, *31*, 100872. https://doi.org/10.1016/j.jwpe.2019.100872

Garg, V. K., & Kaushik, P. (2008). Influence of textile mill wastewater irrigation on the growth of sorghum cultivars. *Applied ecology and environmental research*, *6*(1), 1-12.

Ghormade, V., Deshpande, M. V., & Paknikar, K. M. (2011). Perspectives for nano-biotechnology enabled protection and nutrition of plants. *Biotechnology advances*, *29*(6), 792-803. https://doi.org/10.1016/j.biotechadv.2011.06.007

Guo, H., Liu, Y., Chen, J., Zhu, Y., & Zhang, Z. (2022). The effects of several metal nanoparticles on seed germination and seedling growth: a meta-analysis. *Coatings*, *12*(2), 183. https://doi.org/10.3390/coatings12020183

Holkar, C. R., Jadhav, A. J., Pinjari, D. V., Mahamuni, N. M., & Pandit, A. B. (2016). A critical review on textile wastewater treatments: possible approaches. *Journal of environmental management*, *182*, 351-366. https://doi.org/10.1016/j.jenvman.2016.07.090

Kanan, A. H., Marine, S. S., Raihan, F., Redowan, M., & Miah, M. (2014). Textile effluents changes physiochemical parameters of water and soil: Threat for agriculture. *African Journal of Agronomy*, *2*(10), 219-223.

Kaushik, P., Garg, V. K., & Singh, B. (2005). Effect of textile effluents on growth performance of wheat cultivars. *Bioresource Technology*, *96*(10), 1189-1193. https://doi.org/10.1016/j.biortech.2004.09.020

Khan, M. G., Daniel, G., Konjit, M., Thomas, A., Eyasu, S. S., & Awoke, G. (2011). Impact of textile waste water on seed germination and some physiological parameters in pea (Pisum sativum L.), Lentil (Lens esculentum L.) and gram (Cicer arietinum L.). *Asian Journal of Plant Sciences*, *10*(4), 269. http://scialert.net/fulltext/?doi=ajps.2011.269.273&org=11

Khan, S., & Malik, A. (2018). Toxicity evaluation of textile effluents and role of native soil bacterium in biodegradation of a textile dye. *Environmental Science and Pollution Research*, *25*, 4446-4458. https://doi.org/10.1007/s11356-017-0783-7

Kothari, R., Pathak, A. K., Sharma, V., Ahmad, S., Singh, H. M., Singh, R. P., & Tyagi, V. V. (2022). Impact of pollutant load from textile dyeing industry wastewater on biometric growth profile of Vigna radiata. *Bulletin of Environmental Contamination and Toxicology*, *109*(6), 969-976. https://doi.org/10.1007/s00128-022-03491-w

Lellis, B., Fávaro-Polonio, C. Z., Pamphile, J. A., & Polonio, J. C. (2019). Effects of textile dyes on health and the environment and bioremediation potential of living organisms. *Biotechnology Research and Innovation*, *3*(2), 275-290.

Lin, D., & Xing, B. (2007). Phytotoxicity of nanoparticles: inhibition of seed germination and root growth. *Environmental pollution*, *150*(2), 243-250. https://doi.org/10.1016/j.envpol.2007.01.016

Mehdi, B., Mehdi, J., Abolfazl, T., & Yasser, E. (2012). Effects of using wastewater in agricultural production. *African Journal of Microbiology Research*, *6*(1), 1-9.

Mohan, D., & Shukla, S. P. (2022). Hazardous consequences of textile mill effluents on soil and their remediation approaches. *Cleaner Engineering and*

Technology, 100434. https://doi.org/10.1016/j.clet.2022.100434

Najam-us-Sahar, N. U. S., Azhar Hussain, A. H., Ayesha Mustafa, A. M., Rashid Waqas, R. W., Irfan Ashraf, I. A., & Akhtar, M. F. U. Z. (2017). Effect of textile wastewater on growth and yield of wheat (Triticum aestivum L.). http://dx.doi.org/10.25252/SE/17/41133

Pokhriya, P., Rajput, R., Nautiyal, P., Panwar, P., Pandey, D., Daverey, A., & Arunachalam, K. (2020). Impact assessment of textile effluent on health and microbiota of agricultural soil in Bhagwanpur (Uttarakhand), India. *SN Applied Sciences*, *2*(9), 1-10. https://doi.org/10.1007/s42452-020-03336-3

Rajani, Meena, R. K., & Mishra, P. (2023). Madhuca longifolia leaf extract mediated synthesis of ZnO nanoparticles and their Antibacterial, Antioxidant, and Photocatalytic activity. *IJRPS, 14(1)*, 1-9. http://dx.doi.org/10.26452/ijrps.v14i1.4175

Rathod, M. C., Senjaliya, B., & Dhale, D. A. (2015). Effect of textile dye on seed germination of chickpea. *Int J Recent Sci Res*, *6*, 2938.

Ravi, D., Parthasarathy, R., Vijayabharathi, V., & Suresh, S. (2014). Effect of textile dye effluent on soybean crop. *Journal of Pharmaceutical, chemical and Biological sciences*, *2*(2), 111-117.

Rehman, A., Bhatti, H. N., & Athar, H. U. R. (2009). Textile effluents affected seed germination and early growth of some winter vegetable crops: a case study. *Water, air, and soil pollution*, *198*, 155-163. https://doi.org/10.1007/s11270-008-9834-5

Robinson, T., McMullan, G., Marchant, R., & Nigam, P. (2001). Remediation of dyes in textile effluent: a critical review on current treatment technologies with a proposed alternative. Bioresource technology, 77(3), 247-255. https://doi.org/10.1016/S0960-8524(00)00080-8

Roohi, M., Riaz, M., Arif, M. S., Shahzad, S. M., Yasmeen, T., Riaz, M. A., & Mahmood, K. (2016). Varied effects of untreated textile wastewater onto soil carbon mineralization and associated biochemical properties of a dryland agricultural soil. *Journal of environmental management*, *183*, 530-540. https://doi.org/10.1016/j.jenvman.2016.09.005

Sadiq, H., Sher, F., Sehar, S., Lima, E. C., Zhang, S., Iqbal, H. M., & Nuhanović, M. (2021). Green synthesis of ZnO nanoparticles from Syzygium cumini leaves extract with robust photocatalysis applications. *Journal of Molecular Liquids*, *335*, 116567. https://doi.org/10.1016/j.molliq.2021.116567

Singh, J., Gupta, P., & Das, A. (2021). Dyes from Textile Industry Wastewater as Emerging Contaminants in Agricultural Fields. In *Sustainable Agriculture Reviews 50* (pp. 109-129). Springer, Cham. https://doi.org/10.1007/978-3-030-63249-6_5

Tourinho, P. S., Van Gestel, C. A., Lofts, S., Svendsen, C., Soares, A. M., & Loureiro, S. (2012). Metal-based nanoparticles in soil: Fate, behavior, and effects on soil invertebrates. *Environmental Toxicology and Chemistry*, *31*(8), 1679-1692. https://doi.org/10.1002/etc.1880

Yang, T. K., Basu, B., & Ooraikul, F. (2001). Studies on germination conditions and antioxidant contents of wheat grain. *International Journal of Food Sciences and Nutrition*, *52*(4), 319-330.

https://doi.org/10.1080/09637480120057567

Yaqoob, S., Ullah, F., Mehmood, S., Mahmood, T., Ullah, M., Khattak, A., & Zeb, M. A. (2018). Effect of waste water treated with TiO2 nanoparticles on early seedling growth of Zea mays L. *Journal of Water Reuse and Desalination*, *8*(3), 424-431. https://doi.org/10.2166/wrd.2017.163

Yousaf, I. M. R. A. N. A., Ali, S. M., & Yasmin, A. (2010). Germination and early growth response of Glycine max varieties in textile and paper industry effluents. *Pak. J. Bot*, *42*(6), 3857-3863.